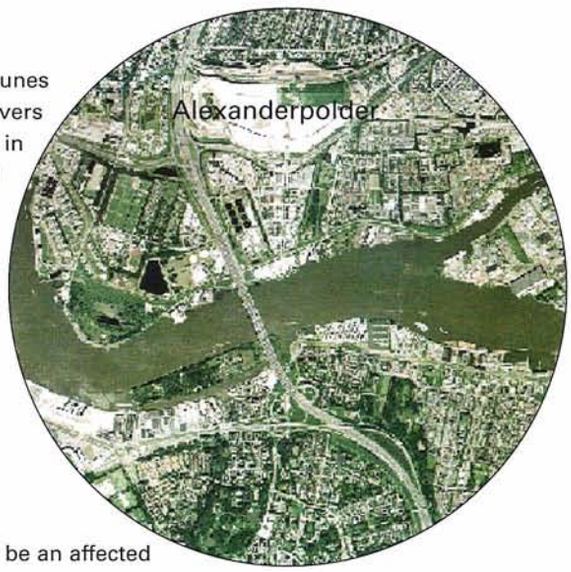
Ministerie van Verkeer en Waterstaat

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties

Breach at Alexanderpolder

Introduction

A large part of the Netherlands is located below sea level. Dunes and dikes protect us from floods originating from the sea, rivers and lakes. The level of protection which we strive to achieve in the Netherlands, is prescribed by law in the so-called "Flood defences Act". Nonetheless, a flood may still occur and result in great economic damages and a large number of affected individuals and casualties.



Following a flood, the material damages to housing, industry and infrastructure is significant. As a direct consequence, many businesses cease to operate and essential services like utilities, ICT and telecom become unavailable. This loss of service is not restricted to the flooded area, but reaches further outside the affected area.

Everyone within the 'threatened area' may be considered to be an affected individual. The number of casualties strongly depends on the depth of the water, the rate at which the water rises and the success of a possible evacuation. In order to start an evacuation, it is necessary to have a realistic expectation of the time and size of an imminent flood. It is possible to forecast a heightened water level, but this forecast is inherently uncertain. It is usually possible to predict a critical situation a few days in advance in the case of rivers, but only half a day to a whole day is available for the sea and lakes. The prediction of high water levels is different from the prediction of a dike breach. Predicting the occurrence of one or more breaches in a dike is more difficult and strongly dependent on the local situation and strength of the dike.

The actual time available for an evacuation of the Western part of the Netherlands, when the area is threatened by floods, is much shorter than the time required for a full evacuation. The required length of time for an evacuation is largely determined by the extent of the flood, the number of affected individuals, the capacity of the transport infrastructure, and the coordination of the evacuation and rescue operations. The available time for an evacuation may be increased by rapid decisions, through the application of traffic management and by adequate communication between authoritiesand civilians.

Three possible flooding scenarios have been developed:

1. A breach near the city of Rotterdam-Alexanderpolder along the river 'Maas'. The water level at the river is equal to the level of protection of dikes ('Flood defences Act'). A strongly urbanized area in South Holland will flood.
2. A multiple breach near the cities of Monster en Katwijk along the sea. The water level at sea is equal to the level of protection of dikes and dunes ('Flood defences Act'). The floodwater will spread through the canal system inside dikering 14 and threat Airport Schiphol.
3. A multiple breach near the cities of Monster en Katwijk (sea) and Rotterdam-Alexanderpolder (river). The water level at the sea and the river is a factor 100 more extreme than the level of protection of dikes ('Flood defences Act').

In this brochure the results of scenario **'Breach at Alexanderpolder'** are presented.

Flooding scenarios

A flooding scenario yields the progression of a flood. It gives insight into questions as: how large is the flooded area, how fast will the water spread and what is the water depth on a certain location? There are several different scenarios conceivable. Important components of a scenario are the locations of the breaches (in a real disaster there are often more than one) and the hydraulic load on the dam or dike. Further, the force of the flood wave depends strongly on the local situation behind the dikes and dunes.

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A design flood scenario (1/100,000 per year) depends on the criteria employed for it, like the extent, the damage, the demand for aid or the capacity of the emergency agencies. At the moment there is no consensus on an unambiguous design flood scenario. It does however seem to be sensible to take several flooding scenarios as a starting point for preparation, and build in flexibility for the demand on aid.

For the analysis of the scenarios a hydrodynamic and a damage/casualties model has been used. These models use data as water levels, wave heights at seas and in the river, land surface height, regional water courses, land use, number of inhabitants and the infrastructure within 'dikering Centraal-Holland' (Hoogwater Informatie Systeem instrumentarium). This 'dikering' (14) encompasses amongst others the cities of Rotterdam, Amsterdam and The Hague but also Airport Schiphol. The 'dikering' is situated in three provinces: South Holland, North Holland and Utrecht.

Description of a breach in the river dike at Rotterdam-Alexanderpolder

A breach at the Alexanderpolder will flood a strongly urbanized area in South Holland (37,000 ha). The final damage on residences, businesses and infrastructure and damage by businesses ceasing to operate is estimated at approximately € 38 billion. As a result of (amongst others) drowning or hypothermia there will most likely be a large amount of casualties. Depending on the success of the evacuation, casualties are estimated to amount between 3,000 and 7,000 people. Important roads for evacuation are the highways (A12 to the east, the A13 and A4 in northern direction and the A16 towards the south).

The dike fails to the west of the Brienenoord bridge. The water level and waves on the river are more or less conform to the protection level as described by law (in the before mentioned 'Flood defences Act'). This protection level is determined by a certain chance of occurrence of water levels. The analysed situation is caused by a combination of storm at sea and river discharge. In this scenario the 'Maeslantkering' is not closed.
After the dike has failed, water will continue to flow into the polder from the river for a period of weeks. The river discharge provides a continuous and large supply of water during this period. A large amount of water will flow into the area because of the low elevation of the polders behind the breached dike. Closing the breached dike is a difficult process that can take up to several days to weeks. This is caused by high flow rates through the breach and the large erosion gap in and around the breach with a depth of probably more than 10 meters.

Extent of flooding
Within one hour, Kralingen will be flooded. After two hours the water has passed the A20 and the A16, and has flooded Cappelle a/d IJssel. Some highways are high enough to function as a dike but because of overpasses and fly-overs the water will continue to spread. Four hours after the breach the city centre of Rotterdam is flooded. At that moment the water depth at Kralingen is still less than two meters. After seven hours Hilligersberg will be flooded completely and the water depth in the Alexanderpolder will locally exceed three meters. After one day the water will reach Zoetermeer. An area of 10,000 ha is flooded. During the second day the area between Cappelle a/d IJssel and Gouda will be flooded. Airport Zestienhoven is out of order. The water depth in Cappele a/d IJssel has reached more than three meters. After two days the total extent of the flood is 15,000 ha. On the third day the water passes the A12 and flows in the direction of Boskoop. Therefore the A12 can no longer be used as an escape or evacuation route. The so-called 'green heart' has changed into a 'blue heart'.
Fourteen days after the start of the flood an area of 37,000 ha is flooded. This is de maximum extent of the flooded area. Smaller dikes along the canal system inside dikering 14, high roads and relatively high elevated areas limit the extent of the flooded area. The breach in the dike might now be closed and the recovery of the area can be started.

Damage
Based on the water depth and the land use, the damage of the flood is calculated. For the considered flood from the river the expected damage is € 38 billion. One third of this damage is already caused after one day. The damage is concentrated in the towns of Rotterdam, Cappelle a/d IJssel, Nieuwerkerk a/d IJssel and Zoetermeer, these areas are most densely populated.

Evacuation and the decision to evacuate
The water level expected to cause the failure of the dike near Rotterdam can be predicted approximately 24 hours in advance. The expected water level is based on predictions of wind direction and speed, tidal fluctuations and river discharge. This prediction is impaired by uncertainty; this uncertainty will be reduced when the prediction-horizon is shortened. To prevent casualties, it is desirable to decide to evacuate as early as possible.

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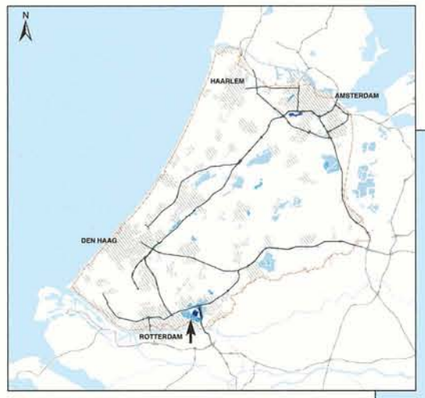
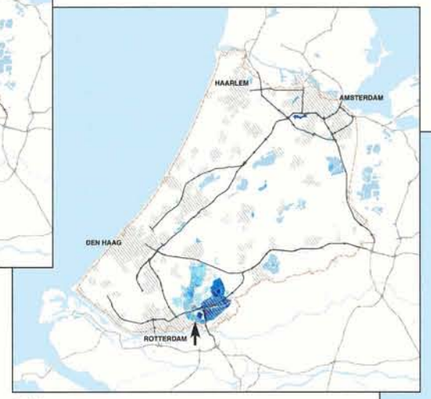
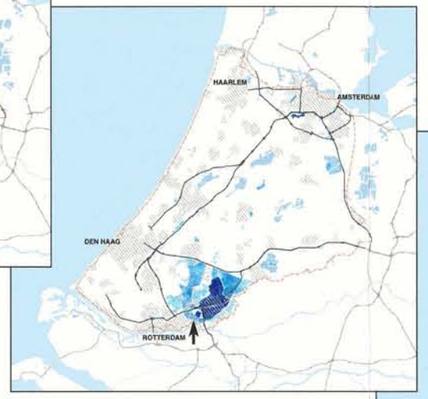


4 hours

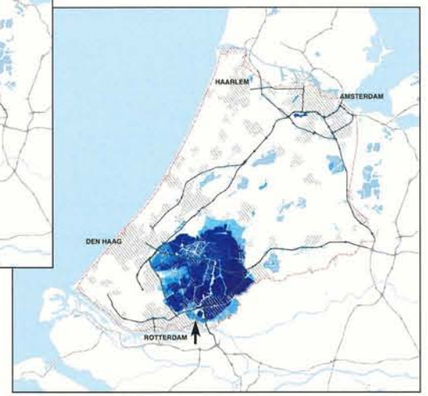


24 hours



48 hours

1 week



Maximum waterdepth

PROGRESSION OF FLOODING AFTER ALEXANDERPOLDER BREACH

Time to flooding	
Road and municipal boundary	**Hours**
Rotterdam	0
A16	1
A20	3
N209, Zevenhuizen, Moerkappelle Bergschenhoek and Capelle a/d IJssel	8
N472, N471 and Nieuwekerk a/d IJssel	9
Berkel and Rodenrijs	14
Bleiswijk	15
Zoetermeer	24
Moordrecht	37
Pijnacker-Nootdorp	48
A12, Waddinxveen	60
N209, Rijnwouden	72
Zoeterwoude	84
Leidschendam-Voorburg	140

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

water depth [m]
- no water
- < 1
- 1 –2
- 2 –3
- 3 –4
- > 4

0 5 10 Kilometres

Affected individuals and casualties in flooded area

Affected individuals per municipality

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Affected individuals per municipality
- no affected induviduals
- 1 –100
- 100 –1.000
- 1.000 –10.000
- 10.000 –100.000
- > 100.000

0 5 10 Kilometres

Casualties (evacuation and traffic management)

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Casualties per community
- no casualties
- 1 –10
- 10 –100
- 100 –1.000
- 1.000 –10.000
- > 10.000

0 5 10 Kilometres

Damages in flooded area

Damages per municipality

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Damages per community
- < 0,5 mln
- 0,5 –5 mln
- 5 –50 mln
- 50 –500 mln
- 500 –5.000 mln
- > 5.000 mln

0 5 10 Kilometres

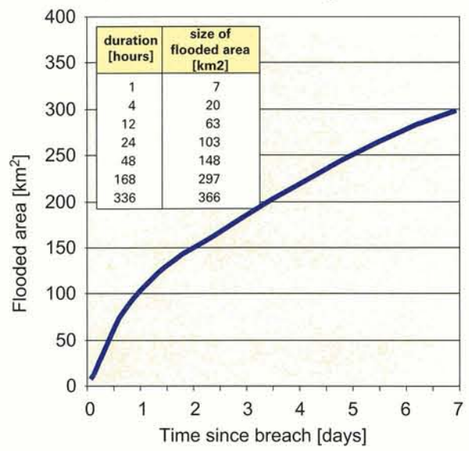
Damages per hectare

Legend
- Municipal area
- Lakes
- Boundary of dikering 14
- Municipal boundaries
- Roads
- Breach location

Damages per hectare
- no damage
- < 0,05 mln
- 0,05 –0,5 mln
- 0,5 –5 mln
- 5 –50 mln
- > 50 mln

0 5 10 Kilometres

Extent of flooding



duration [hours]	size of flooded area [km2]
1	7
4	20
12	63
24	103
48	148
168	297
336	366

Key values				
duration [hours]	**damages [million euro]**	**number of affected individuals**	**number of casualties***	**number of casualties****
1	900	89,000	50	25
4	3,600	165,000	200	100
12	8,200	261,000	600	300
24	11,900	285,000	1,250	550
48	16,300	329,000	3,700	1,600
168	24,000	456,000	4,100	1,850
336	37,600	505,000	7,000	3,000

* without evacuation
** with preventive evacuation and traffic management

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The assumption is made that all inhabitants of the threatened area will be evacuated to outside the affected area. Furthermore, it is assumed that evacuation takes place from the place of residence and that existing infrastructure is used. Distinction is made in evacuation with and without traffic management (adjusting traffic infrastructure, by which it is presumed that the outflow can on average be increased with 50%). The most important roads used during evacuation are the highways:

- A16 from Brienenoord in the direction of Breda,
- A12 in the direction of Utrecht,
- A13 and A4 in the direction of Amsterdam.

Without traffic management it will take a total of 72 hours for total evacuation; with traffic management this can be reduced to 35 hours.

In the available 24 hours between the decision to evacuate and the predicted start of the flood approximately 65% of all people can be evacuated with efficient traffic management. Without this traffic management about 35% can be evacuated, as is illustrated in the graph and figure shown on the next page.

Casualties

The total number of inhabitants in the flooded area is over 500,000 people. The number of casualties will depend on the number of affected people in the flooded area, the water depth and the rate of increasing water depths. Particularly rapidly rising water levels can cause casualties. A successful evacuation will reduce the possible causalities in the threatened area.

Without any evacuation about 7,000 casualties are expected, which can be regarded as an upper limit. By timely and efficient evacuation, (part of) these casualties can be prevented. With an evacuation that starts 24 hours before the beginning of the flood and traffic management, over 4,000 casualties can be prevented. If this traffic management is not practised only 3,000 casualties can be prevented.

Lessons learned from the scenarios

The rate of spreading of the water and the final extent of the flooded area are strongly dependent on the location of the (multiple) breach(es) and on the water levels and wave heights at sea and in the river. It also appears that it is very unlikely that the whole 'dikering Centraal Holland' will be flooded. This is a recent notion, because even the Delta commission has assumed that the whole of Centraal-Holland will be flooded up to the border of the dikes. This assumption is based on the flood of 1953. Even in very extreme circumstances more than half of the 'dikering Centraal Holland' will not be flooded because of the limited supply of water, the relatively high position of the dunes along the coast, the relatively large extent of 'dikering 14' and the presence of other dikes and dams inside the 'dikering'. The extent however will be that large that virtually always borders of communities, waterboards, safety regions and sometimes even provinces are crossed.

However, there also appears to be preparation time for government as well as citizens, to act and prevent damage and casualties. This time consists of the prediction time of the critical water level and the time needed for the water to spread over the land.

In the present example for evacuation no difference is made in the phasing of evacuation streams; also no people are evacuated to 'safe havens' such as high buildings and higher situated grounds inside the flooded areas. Until today it has always been assumed that everyone, more or less at the same time, will be evacuated to outside the 'threatened area'. By making an area-specific evacuation plan more people can be brought to safety and potential casualties can be prevented. In this plan failure of utility services, ICT and telecom services will have to be taken into account, as will the availability of personnel, the preservation of the public order and relief.